CH # 02 MEASURMENTS

SYSTEMS OF UNITS:

"A set of units based on fundamental and derived unit is known as system of units."

SYSTEMS OF UNITS

i. M.K.S system. Or System International (S.I).
ii. C.G.S system.
iii. F.P.S System.

SYSTEM INTERNATIONALUNITS (SI or M.K.S UNITS):

"The system of unit in which units for length, mass and time are meter, kilogram and second is known as system international or M.K.S system."

Advantages of SI units:

- These units are used in all over the world.
- Mathematical measures are easier in SI units.

C.G.S SYSTEM:

"The system of unit in which units for length, mass and time are centimetre, gram and second is known as C.G.S system."

F.P.S SYSTEM:

"The system of unit in which units for length, mass and time are foot, pound and second is known as F.P.S system."

METER (m):

"It is defined as the distance between two marks on a platinum-iridium bar kept at 0^0C in the international Bureau of weights and measures near Paris or one meter = 165076373 wavelength of Krypton (Kr radiations)."

KILOGRAM (Kg):

"The mass of the cylinder of specific dimension of platinum-iridium alloy kept in the international bureau of weights and measures near Paris is taken to be the standard of 1kg."

SECONDS (Sec):

"Earlier seconds was defining as $1/86400^{th}$ of the mean solar day or 1 sec is 9,192,631,770 periods of vibrations of CS-133".

FUNDAMENTAL/BASIC QUANTITIES:

"Quantities which cannot be further solving into anything are called fundamental quantities."

E.g. length, mass, time etc.

DERIVED QUANTITIES:

"Quantities which can be express in terms of fundamental quantities are called derived quantities. E.g. Area, Volume, Density etc."

FUNDAMENTAL/BASIC UNITS:

"Units of fundamental quantities are called fundamental units."

DERIVED UNITS:

"Units of derived quantities are called derived units."

BASIC S.I UNITS

No.	Physical quantity	Symbols	Units	Symbols
1.	Length	L	Meter	M
2.	Mass	M	Kilogram	Kg
3.	Time	T	Second	Sec
4.	Electric current	I	Ampere	Amp
5.	Temperature	T	Kelvin	K
6.	Luminous intensity	Iv	Candela	cd
7.	Amount of substance	N	Mole	Mol

DERIVED S.I UNITS

No.	Physical quantity	Symbols	Units	Symbols
1.	Area	A	Meter Square	m^2
2.	Volume	V	Cubic meter	m^3
3.	Frequency	f	Hertz	Hz
4.	Density	ρ	Kilogram per cubic meter	Kg/m^3
5.	Speed and velocity	V	Meter per sec	m/s
6.	Acceleration	a	Meter per sec square	m/s^2
7.	Force	F	Newton	N
8.	Pressure	P	Pascal	Pa
9.	Work, energy and heat	W,E and q	Joule	J
10.	Power	P	Watt	W
11.	Potential difference or E.M.F	V	Volt	V
12.	Electric field	E	Newton per coulomb	N/C
13.	Electric resistance	R	Ohm	Ω
14.	Capacitance	C	Farad	F
15.	Specific heat	C	Joule per kilogram per kelvin	J/Kg.K
16.	Latent heat	L	Joule per kilogram	J/Kg
17.	Thermal conductivity	Q	$Jm^{-1}K^{-1}S^{-1}$	$Jm^{-1}K^{-1}S^{-1}$
18.	Momentum	P	Kilogram meter per second or Newton second	Kg.m/s or N/S
19.	Torque	τ	Newton meter	Nm
20.	Viscosity	V	Newton	N

ERROR:

"The difference between measured and actual value is called error."

TYPES OF ERROR

There are three types of error.

1. PERSONAL ERROR:

"Error arises from a faulty procedure followed an observer is called personal error."

2. INSTRUMENTAL ERROR:

"Error due to imperfection of the instrument or faulty adjustment of the instrument is called instrumental error."

3. RANDOM ERROR:

"Error arise due to a suddenly change of experimental condition. It may be due a suddenly change in temperature pressure, humidity or due to voltage fluctuation etc."

ACCURACY:

"Accuracy is ascertaining the measurement of the physical quantity as close to the actual value as possible."

GRAPH:

"Graph is a straight or curved line, which shows the relationship of two inter-dependent quantities."

TYPES OF VARIABLE (QUANTITIES):

- Independent variables.
- Dependent variables.

- **INDEPENDENT VARIABLES (QUANTITIES):**

  "The quantity which is changed at will is called independent variable."

- **DEPENDENT VARIABLES (QUANTITIES):**

"The quantity which changes according to any variation in the dependent variable is called dependent variable."

ADVANTAGES OF GRAPH:

- It shows the relation between two physical quantities.
- It shows the change in relation of two physical quantities.
- On the basis of graph we can predict the nature of change in quantities.

USES OF GRAPH:

It is used to find the relation between two variable quantities.

RELATION OF QUANTITIES:

There are two types of relations between dependent and independent quantities.

- Direct proportion.
- Inverse proportion.

1. DIRECT PROPORTION:

"Relation of two quantities in which change in one quantity causes change in the other with the same ratio is called direct proportion."

EXAMPLES:

- Volume and absolute temperature of a gas are directly proportional to each other.
  Example: $V \alpha T$.
- Resistance and length of a resistor are directly proportional to each other.
  Example: $R \alpha L$.

NATURE OF GRAPH:

If two quantities are directly proportional to each other than graph between them is a straight line.

2. INVERSE PROPORTION:

"Relation of two quantities in which change in one quantity causes change in other with reciprocal ratio is called inverse proportion."

EXAMPLES:

- Volume and pressure of a gas are inversely proportional to each other ($V \alpha 1/P$).
- Resistance and area of cross section of a wire are inversely proportional ($R \alpha 1/A$).

NATURE OF GRAPH:

If two quantities are inversely proportional to each other than graph between them is a curve line.

SOME MEASURING INSTRUMENTS:

1. VERNIER CALIPER:

"It is an instrument used to measure the distance accurately up to 0.1mm or 0.01 cm."

Vernier constant (V.C) or least count (L.C):

"Vernier constant or the least count is the minimum measurement that can be measured by Vernier Calliper."

Least count = 1 main scale division – 1 Vernier scale division

L.C = 1 mm – 0.9 mm

L.C = 0.1 mm or 0.01 Cm

OR

$$\text{Least count} = \frac{\text{Value of one main scale division}}{\text{Total number of vernier scale division}}$$

$$\text{L. C} = \frac{1}{10}$$

L.C = 0.1 mm or 0.01 Cm

Zero error:

"On closing the jaws if the zero of the main scale does not coincide with the zero of the Vernier scale then the instrument has zero error."

- **Positive zero error:**

  "On closing the jaws if the zero of the Vernier scale is on the right of the main scale then the zero error is positive."

- **Negative zero error:**

  "On closing the jaws if the zero of the Vernier scale is on the left of the main scale then the zero error is negative."

2. MICROMETER SCREW GAUGE:

"It is an instrument used to measure the distance accurately up to 0.01mm or 0.001 cm."

Pitch of the screw gauge:

"Distance between the two consecutive threads of the linear screw is called pitch."

Least count (L.C) of the screw gauge:

"Least count is the minimum measurement that can be measured with the help of screw gauge."

$$\text{Least count} = \frac{\text{Pitch of the screw gauge}}{\text{Number of division on the circular scale}}$$

$$\text{L. C} = \frac{1}{100}$$

L.C = 0.01 mm or 0.001 Cm

Zero error:

"On closing the studs if the zero of circular scale does not coincide with reference line of linear scale then the instrument has zero error."

- **Positive zero error:**

  "On closing the studs if the zero of circular scale is above the main scale then the zero error is positive."

- **Negative zero error:**

  "On closing the studs if the zero of circular scale is below the main scale then the zero error is negative."

3. **PHYSICAL BALANCE:**

   "It is an instrument used to measure the mass of an object."

4. **MEASURING OR GRADUATED CYLINDER:**

   "It is a device used to measure the volume of liquid."

5. **STOP WATCH:**

   "It is a device used to measure the time."

TABLE 1.4 Prefixes for SI Units

Power	Prefix	Abbreviation
10^{-24}	yocto	y
10^{-21}	zepto	z
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10^{1}	deka	da
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z
10^{24}	yotta	Y

TABLE 1.2 Masses of Various Bodies (Approximate Values)

Body	Mass (kg)
Visible Universe	$\sim 10^{52}$
Milky Way galaxy	7×10^{41}
Sun	1.99×10^{30}
Earth	5.98×10^{24}
Moon	7.36×10^{22}
Horse	$\sim 10^{3}$
Human	$\sim 10^{2}$
Frog	$\sim 10^{-1}$
Mosquito	$\sim 10^{-5}$
Bacterium	$\sim 10^{-15}$
Hydrogen atom	1.67×10^{-27}
Electron	9.11×10^{-31}

TABLE 1.3 Approximate Values of Some Time Intervals

	Interval (s)
Age of the Universe	5×10^{17}
Age of the Earth	1.3×10^{17}
Average age of a college student	6.3×10^{8}
One year	3.16×10^{7}
One day (time for one rotation of the Earth about its axis)	8.64×10^{4}
Time between normal heartbeats	8×10^{-1}
Period of audible sound waves	$\sim 10^{-3}$
Period of typical radio waves	$\sim 10^{-6}$
Period of vibration of an atom in a solid	$\sim 10^{-13}$
Period of visible light waves	$\sim 10^{-15}$
Duration of a nuclear collision	$\sim 10^{-22}$
Time for light to cross a proton	$\sim 10^{-24}$

TABLE 1.1 Approximate Values of Some Measured Lengths

	Length (m)
Distance from the Earth to most remote known quasar	1.4×10^{26}
Distance from the Earth to most remote known normal galaxies	9×10^{25}
Distance from the Earth to nearest large galaxy (M 31, the Andromeda galaxy)	2×10^{22}
Distance from the Sun to nearest star (Proxima Centauri)	4×10^{16}
One lightyear	9.46×10^{15}
Mean orbit radius of the Earth about the Sun	1.50×10^{11}
Mean distance from the Earth to the Moon	3.84×10^{8}
Distance from the equator to the North Pole	1.00×10^{7}
Mean radius of the Earth	6.37×10^{6}
Typical altitude (above the surface) of a satellite orbiting the Earth	2×10^{5}
Length of a football field	9.1×10^{1}
Length of a housefly	5×10^{-3}
Size of smallest dust particles	$\sim 10^{-4}$
Size of cells of most living organisms	$\sim 10^{-5}$
Diameter of a hydrogen atom	$\sim 10^{-10}$
Diameter of an atomic nucleus	$\sim 10^{-14}$
Diameter of a proton	$\sim 10^{-15}$